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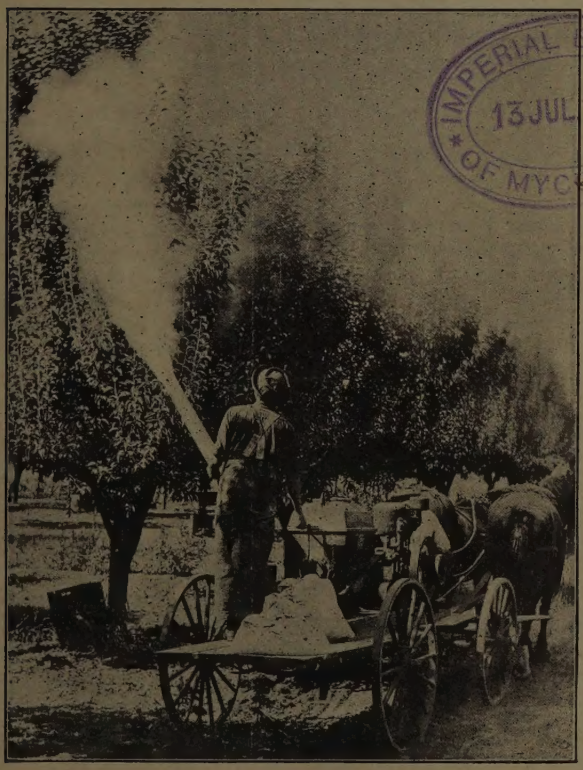
MICHIGAN AGRICULTURAL COLLEGE

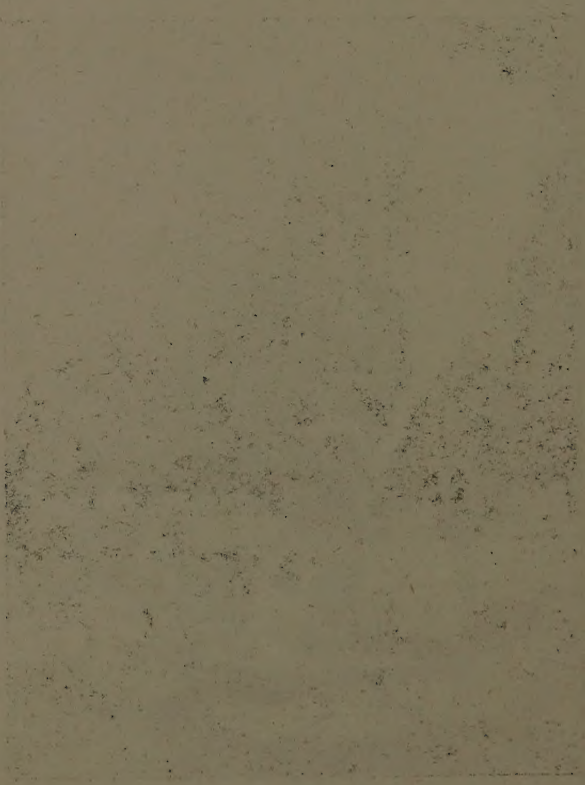
EXPERIMENT STATION

DUSTING AND SPRAYING EXPERIMENTS OF 1918 AND 1919



BY
W. C. DUTTON
HORTICULTURAL SECTION

EAST LANSING, MICHIGAN
1920



DUSTING AND SPRAYING EXPERIMENTS

OF

1918 AND 1919

BY W. C. DUTTON

INTRODUCTORY

This bulletin contains reports of the results of a series of dusting and spraying experiments conducted by the Horticultural Section during the seasons of 1918 and 1919. This work included comparisons of dusting materials, lime-sulphur solution, bordeaux, dry lime-sulphurs, lead arsenate, calcium arsenate and magnesium arsenate. These materials were used on apples, cherries, plums, peaches, currants and potatoes.

EXPLANATORY NOTES

The meaning of several terms used may not be familiar to all. To avoid repetition, the following explanations are in order:

DUSTING TERMS

90-10 mixture. A dusting mixture containing 90% dusting sulphur and 10% dry lead arsenate.

85-15 mixture. One containing 85% sulphur and 15% lead arsenate.

3 in 1 dust. A mixture containing sulphur, tobacco dust and lead arsenate.

50-40-10 mixture. One containing 50% sulphur, 40% filler (usually hydrated lime) and 10% lead arsenate.

Concentrated dust. A mixture containing only sulphur and lead arsenate. Usually made by the 85-15 or 90-10 formula.

Dilute dust. A mixture containing 40 to 50% sulphur, 35 to 50% filler (hydrated lime, talc or gypsum) and 10 to 15% lead arsenate.

SPRAYING TERMS

1 to 40. This refers to lime-sulphur of 31 to 33 degree Beaume test used at the rate of 1¼ gallons in 50.

4-4-50 bordeaux. This refers to bordeaux made of 4 pounds stone

lime (or 6 pounds hydrated lime), 4 pounds copper sulphate and 50 gallons water.

GENERAL TERMS

Check plot or tree. Trees or plants which are left untreated to indicate the amount of injury by insects or disease that would develop when not sprayed or dusted.

Count trees. In much of the work, particularly with apples, the fruit from one or more trees in each plot was sorted and classified according to the presence of any injury by insect or disease or by its freedom from such injury. Trees were selected for this purpose that were as uniform as possible. Location of the tree and the size and uniformity of the crop were points considered in selecting them. The number of trees in any plot was in no case limited to the trees from which counts were actually made. The total number in a plot varied from nine to fifty or more.

Pink or cluster application. The application made on apples just before the blossoms open, but after the buds have separated in the cluster.

Calyx application. In the work here reported the calyx application was usually made immediately after the petals had fallen. It could be safely delayed a few days and still control the coddling moth but earlier application insures better control of apple scab.

Other Insects. This term is used in several of the tables showing results of work with apples. This means injury to the fruit by any chewing insect other than coddling moth, such as the lesser apple worm, Tussock moth, fruit worms, etc.

Calcium arsenate. The same as arsenate of lime or arsenate of calcium.

ACKNOWLEDGMENTS

Much of this work was done at several places in the state in orchards belonging to fruit growers. The Horticultural Department is indebted to these growers for their assistance and co-operation in carrying on this work. They are Geo. Winegar & Son, Morrice; B. F. Hall, Belding; Oscar Braman, Grand Rapids; C. W. Garlock, Grand Ledge; James Boyce, Holland; J. C. Maynard and Ed. O'Brien, Grand Rapids. Much of the actual work with experiments on the College grounds was done by Harold Lackey. The duster used at the College was furnished by the Corona Chemical Company, Milwaukee, Wisconsin. R. E. Loree and M. M. Brown assisted in securing records in 1918. The picture on the front cover is used by the courtesy of D. F. Fisher of the United States Department of Agriculture.

EXPERIMENTS WITH APPLES

The work done with apples in 1918 was largely a comparison of the dusting and spraying methods of application. Tests were also made with calcium arsenate and Sherwin-Williams dry lime-sulphur.

In 1919 the work consisted mainly of tests of the dry lime-sulphurs and of several arsenicals. Some dusting was also done.

EXPERIMENTS IN 1918

COMPARISONS OF DUSTING WITH SPRAYING AND CALCIUM ARSENATE WITH LEAD ARSENATE AT MORRICE

In the orchard at Morrice, belonging to Geo. Winegar and Son, dusting and spraying experiments were continued. Experimental work had been carried on in this orchard during 1915, 1916 and 1917. The results of this earlier work have already been published.* The entire

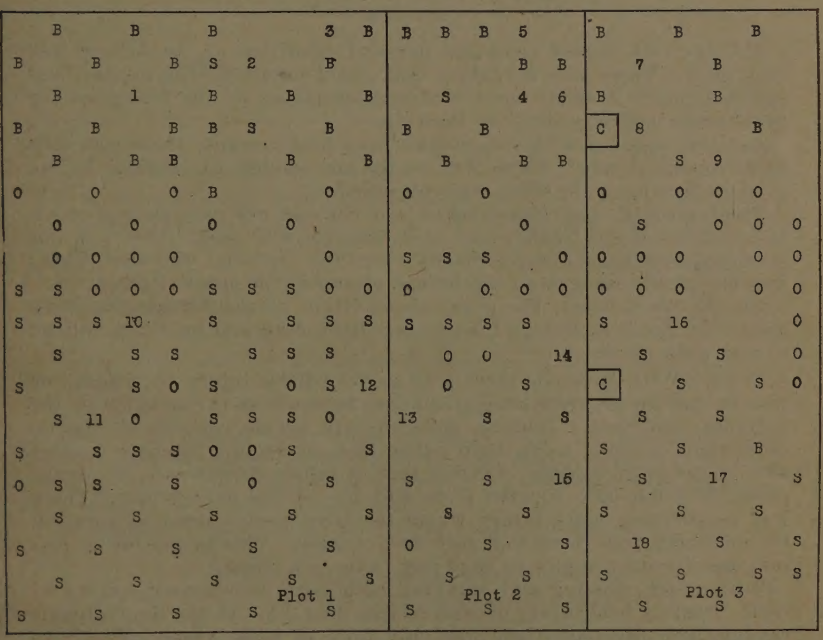


CHART I. Diagram showing arrangement of trees and plots in the Winegar orchard at Morrice. B, Baldwin; S, Stark; C, check; O, other varieties. The numbers indicate count trees. Plot 1, dusted; Plot 2, sprayed with lime-sulphur and calcium arsenate; Plot 3, sprayed with lime-sulphur and lead arsenate.

*Special Bulletin No. 87. Dusting and Spraying Experiments with Apples.

orchard was used, but trees of any variety other than Stark and Baldwin were not considered in the results.

Materials. The orchard was divided into three plots with check trees for each variety. They were arranged so that both Stark and Baldwin were included in each plot. The arrangement of trees and plots is shown in Chart I. The different plots were treated as follows:

Plot 1. Dusted. 90-10 mixture.
Plot 2. Sprayed. Lime-sulphur, 1 to 40 and calcium arsenate (dry), 1 lb. in 50 gal.
Plot 3. Sprayed. Lime-sulphur, 1 to 40 and lead arsenate (paste), 2½ lbs. in 50 gal.

Applications. The four regular application were made at the following periods:

1st. Pink or cluster application.
2nd. Calyx application.
3rd. Sixteen days after second.
4th. August 1st.

RESULTS

Foliage. On *dusted* trees the physical condition of the foliage was very good. There was no injury that could be attributed to the dusting materials. A small amount of scab developed on the foliage of the Stark trees, but very little on Baldwin.

On trees *sprayed* with *lime-sulphur and lead arsenate* there was very little foliage injury. There was really not enough to consider so far as the effect upon the trees was concerned.

Trees *sprayed* with *lime-sulphur and calcium arsenate* showed much more foliage injury than where lead arsenate was used. This was not so severe as in some other orchards where this material was used. There was practically no scab on the foliage of any of the sprayed trees.

On the *check* trees, the physical condition of the foliage was very good. On Baldwin foliage there was a little scab and on Stark foliage it was quite noticeable.

Fruit. With *Baldwin* there was so very little injury by disease or insects that no accurate comparison can be made as to the value of the different materials. Dusting gave slightly better control of insects, other than coddling moth, than either lead or calcium arsenate applied with water as the carrier. Of this type of injury there was 7.5% on the check, 3.8% on both sprayed plots and 1% on the dusted plot. There was no coddling moth injury where the trees were dusted or sprayed. On the check tree there was only 3.8% injury. This is too low a percentage of wormy apples to be of any value as a check.

With *Stark*, dusting and spraying both gave satisfactory control of scab. Dusting held injury by scab to less than 2%. In the lime-sulphur-calcium arsenate plot, there was only 2.5% of scab injury. The lime-sulphur-lead arsenate plot showed 5.4% of scabby fruit. This was probably due, in part at least, to part of the count trees being in lower

TABLE I.—RESULTS WITH BALDWIN AT MORRICE, 1918.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Dusted	26	1	3563	98.88	0.39	0	0.73
		2	3679	98.15	0.78	0	1.06
		3	4873	97.66	0.98	0	1.35
Totals			12115	98.16	0.75	0	1.08
Sprayed Lime Sulphur and Calcium Arsenate	13	4	3929	93.63	1.78	0	4.58
		5	3565	96.52	0.39	0	3.08
		6	1968	95.93	0.35	0	3.71
Totals			9462	95.20	0.96	0	3.83
Sprayed Lime Sulphur and Lead Arsenate	11	7	6035	94.86	1.72	0	3.41
		8	4574	94.95	0.80	0	4.24
		9	2745	95.70	0.36	0	3.93
Totals			13354	95.06	1.13	0	3.80
Check	1	C	2282	87.42	1.14	3.85	7.58

TABLE II.—RESULTS WITH STARK AT MORRICE, 1918.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Dusted	58	10	3853	97.69	1.81	0	0.49
		11	3595	98.38	1.00	0.02	0.58
		12	2437	95.65	3.48	0	0.94
Totals			9885	97.54	1.93	0.01	0.63
Sprayed Lime-Sulphur and Calcium Arsenate	21	13	2666	93.92	3.37	0.15	2.55
		14	2351	94.51	1.99	0.08	3.44
		15	2802	96.71	2.31	0	0.963
Totals			7819	95.10	2.58	0.07	2.25
Sprayed Lime-Sulphur and Lead Arsenate	26	16	1535	93.81	4.36	0.06	1.82
		17	1849	92.37	6.16	0.21	1.24
		18	4077	92.61	5.32	0.36	1.74
Totals			7461	92.80	5.33	0.26	1.63
Check	1	C	1229	52.31	16.48	27.50	5.45

ground. For insects, other than coddling moth, all materials gave nearly complete control. All materials gave almost perfect control of coddling moth. The amount of injury—27.5%—on the check tree was high enough for a good comparison.

The tabulated results of all counts are given in Tables I. and II.

COMPARISON OF DUSTING WITH SPRAYING AND CALCIUM ARSENATE WITH LEAD ARSENATE AT MUIR

Work was continued at Muir in the Northern Spy orchard belonging to Mr. Oscar Braman. The principal object of this work was to get further information as to the effect of the different materials on the foliage.

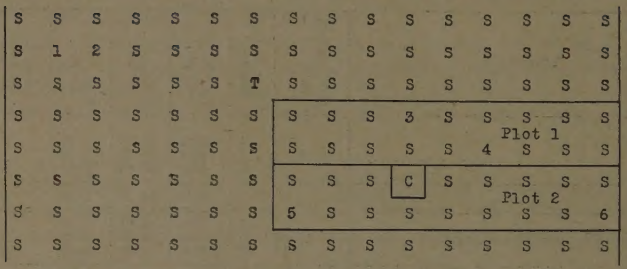


CHART II. Diagram showing arrangement of trees and plots in the Braman orchard at Muir. S, Northern Spy; C, check; T, water tank. Numbers indicate count trees. Plot 1, sprayed with lime-sulphur and lead arsenate; Plot 2, sprayed with lime-sulphur and calcium arsenate. The entire orchard of 40 acres, except Plots 1 and 2 was dusted.

Materials. The main part of the orchard was dusted by Mr. Braman. A block of 36 trees near the middle of the orchard was used for the spraying materials. One of these trees was left untreated as a check. The block of 36 trees was divided into two plots and treated as follows:

Plot 1. Lime-sulphur, 1 to 50, and lead arsenate (dry), 1½ lbs. in 50.

Plot 2. Lime-sulphur, 1 to 50, and calcium arsenate, 1 lb. in 50.

Plot 3. This included the entire orchard other than Plots 1 and 2.

For the first two applications, a 3 in 1 mixture was used and for the last two an 85-15 mixture was used. The arrangement of the trees and plots is shown in Chart II.

Applications. Four applications were made on all plots. They were made at the following periods:

1st. Pink or cluster application.
2nd. Calyx application.
3rd. Two weeks after second.
4th. First week in August.

The spraying was done with a spray gun. 200 to 225 lbs. pressure was maintained. All dusting was done at night, except the last application, by Mr. Wolverton, the man directly in charge of the orchard. For each application, material was applied to one side of each row during one night and to the opposite side the next night. The fourth application was made in the same manner, only during calm periods in day time.

RESULTS

Foliage Injury. The foliage on all *dusted* trees was in excellent physical condition and free from disease.

The foliage of the trees in the *lime-sulphur-lead arsenate* plot was injured some, but not seriously. Only a small percentage of the leaves showed any injury. There was no disease.

The foliage of trees in the *lime-sulphur-calcium arsenate* plot was severely injured by the calcium arsenate, but not badly enough to cause many leaves to drop during the summer. There was no disease on these leaves.

FIG. 1. DUSTED. Typical leaves from Northern Spy trees dusted with sulphur and lead arsenate. They are vigorous and free from injury.

FIG. 2. CALCIUM ARSENATE. Typical leaves from Northern Spy trees sprayed with lime-sulphur and calcium arsenate. There was considerable arsenical injury.

FIG. 3. LEAD ARSENATE. Typical leaves from Northern Spy trees sprayed with lime-sulphur and lead arsenate. There was some injury but not so severe as where calcium arsenate was used.

None of the foliage of *sprayed* trees was in the same clean, bright condition as that on the *dusted* trees.

The foliage of the *check* trees was in very good physical condition. There was a small amount of scabby leaves.

TABLE III.—RESULTS WITH NORTHERN SPY AT MUIR, 1918.

Treatment.	No. of Trees in plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Leaf Roller. Per cent.	Codling. Per cent.	Other Insects, Per cent.
Dusted	Entire orchard except 36 trees	1	1006	96.32	2.49	0.79	0.20	0.20
		2	1096	94.54	1.27	2.46	0.27	1.46
Totals			2104	95.39	1.85	1.66	0.24	0.86
Lime-Sulphur and Lead Arsenate	18	3	1538	95.90	0.39	3.64	0	0.64
		4	2118	93.81	1.04	5.05	0.05	0.05
Totals			3656	96.69	0.77	4.46	0.03	0.05
Lime-Sulphur and Calcium Arsenate	17	5	7535	97.07	0.51	2.22	0	0.19
		6	1027	94.55	2.43	3.02	0	0
Totals			2562	96.06	1.29	2.54	0	0.17
Check	1	C	540	88.33	5.93	5.56	0	0.18

Fruit. Because of the very low percentage of scabby apples on the check tree, no comparison can be made as to the fungicidal value of the different materials. The same is true with regard to insects. There is some difference in the amount of leaf roller injury, but this is probably due more to a spotted infestation than to the insecticide used.

The fruit from two dusted trees, two trees in each sprayed plot and from the check tree was sorted and counted. The results are shown in Table III.

A COMPARISON OF DUSTING WITH SPRAYING AT BELDING.

A comparison was again made of dusting and spraying at Belding in the Baldwin orchard belonging to Mr. B. F. Hall. The object of this work was to compare the fungicidal and insecticidal value of the two methods of application, also to study the effect upon the foliage of the different materials. The experimental plots were located in the south-east corner of the 100-acre orchard. The trees are eighteen years old.

Materials. A block of eighty trees was divided into two plots. One plot was dusted and the other one sprayed. A tree was left untreated as a check. The plots were treated as follows:

Plot 1. Sprayed. Lime-sulphur, 1 to 40, and lead arsenate (dry), 1¼ in 50.

Plot 2. Dusted. 85-15 and 3 in 1 mixtures.

The 85-15 mixture was used for the first two applications and the 3 in 1 mixture for the last two. There was no 85-15 mixture available for these applications. All the dusting materials were furnished by Mr. Hall. The arrangement of the plots is shown in Chart III.

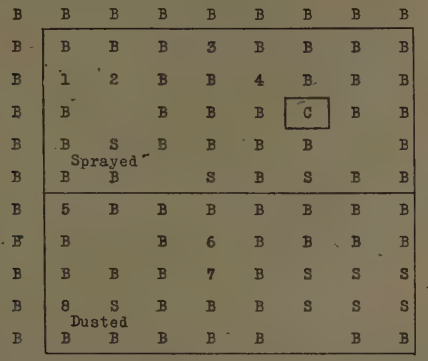


CHART III. Diagram showing arrangement of trees and plots in the B. F. Hall orchard at Belding. B, Baldwin; C, check; S, small trees. Numbers indicate count trees.

Applications. Four applications were made as follows:

1st. The pink or cluster application.
2nd. The calyx application.
3rd. Two weeks after second.
4th. First week in August.

The dusting was done with a large power duster. The trees were dry when all dusting was done, except for the last application. The trees were wet from a light shower which fell just before the dusting was done. The spraying was not always done uniformly as the sprayer frequently did not maintain a satisfactory pressure.

RESULTS.

Foliage. On *dusted* trees there was no foliage injury but a very small amount of scab.

On *sprayed* trees there was no scab but a small amount of foliage injury. The injury was very slight.

On the *check* there was no injury but some scab.

TABLE IV.—RESULTS WITH BALDWIN AT BELDING, 1918.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Sprayed Lime-Sulphur and Lead Arsenate	33	1	1315	89.58	9.20	0	1.29
		2	1915	90.28	9.39	0	0.57
		3	1031	90.59	8.92	0	0.48
		4	991	92.73	5.14	0	2.12
Totals			5252	90.63	8.39	0	1.02
Dusted	31	5	1144	95.45	2.09	0.96	1.49
		6	1746	96.25	1.87	0.22	1.65
		7	2141	98.36	0.70	0.18	0.75
		8	1272	96.22	2.83	0.08	0.86
Totals			6371	96.81	1.71	0.31	1.16
Check	1	C	1324	62.08	36.02	0.53	1.36

Scab control. *Dusting* gave almost complete control of scab on the fruit. There was only 1.7% of scabby fruit on the count trees. On the *sprayed* trees there was nearly 6% more of scabby apples than on dusted trees. The failure of the sprayer to work satisfactorily at all times was probably responsible for some of the scab on these trees. On the check tree there was 36.0% of scabby apples. This was high enough to give a good check on the treated trees.

Insect Control. There was so little insect injury, on the check tree, that no comparison can be made.

The tabulated results of all counts are given in Table IV.

EXPERIMENTS AT GRAND LEDGE

Spraying experiments were continued in the orchard near Grand Ledge belonging to Mr. C. W. Garlock. The work done there in 1917 has already been reported.* The work here in 1918 was in two parts:

(1) a test on Baldwin of Sherwin-Williams dry lime-sulphur and (2) a test of calcium arsenate on Ben Davis.

A TEST OF DRY LIME-SULPHUR ON BALDWIN

Materials. There were three rows of Baldwin trees with ten trees in a row. Each row was used as a separate plot. The dry lime-sulphur was used at two strengths and standard liquid lime-sulphur was used for comparison. The plots were treated as follows:

Plot 1. Sherwin-Williams dry lime-sulphur, 5½ lbs. in 50.
Plot 2. Sherwin-Williams dry lime-sulphur, 3 lbs. in 50.
Plot 3. Liquid lime-sulphur, 1 to 40.

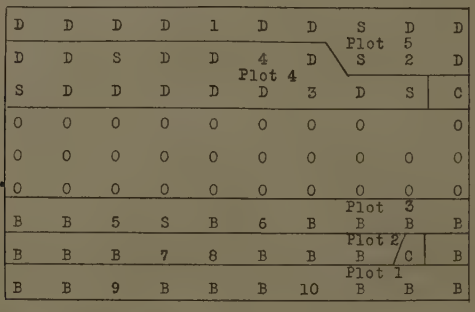


CHART IV. Diagram showing arrangement of trees and plots in the Garlock orchard at Grand Ledge. D, Ben Davis; B, Baldwin; C, check; O, other varieties; S, small tree. Numbers indicate count trees. Plot 1, Sherwin-Williams dry lime-sulphur, 5½ in 50; Plot 2, Sherwin-Williams dry lime-sulphur, 3 in 50; Plot 3, dilute lime-sulphur; Plot 4, calcium arsenate; Plot 5, lead arsenate

Lead arsenate (dry) was used on all plots at the rate of 1¼ pounds in 50 gallons. The arrangement of the plots and trees is shown in Chart IV.

*Special Bulletin No. 87. Dusting and Spraying Experiments with Apples.

The results from the use of dry lime-sulphur on Northern Spy in 1917 were not so satisfactory as where the standard lime-sulphur solution was used. It was thought at that time that if the amount used in each fifty gallons was increased so as to contain the same amount of actual sulphur as is found in 1¼ gallons of standard lime-sulphur solution, that the results would be better. Accordingly, it was used at two rates in 1918. First, at the rate of 3 pounds in 50 gallons, which is the maximum strength recommended by the manufacturers, and second, at the rate of 5½ pounds in 50 gallons. This gave about the same amount of sulphur as would be found in 1¼ gallons of lime-sulphur solution testing 32 degrees Beaume.

Application. Four applications were made as follows:

1st. Pink or cluster application.
2nd. Calyx application.
3rd. Two weeks after second.
4th. First week in August.

All spraying was done with a spray gun and with high pressure.

RESULTS

Foliage Injury. There was very little foliage injury in any plot. The foliage of trees sprayed with *dry lime-sulphur* was in slightly better condition than where the standard *lime-sulphur solution* was used, but the injury was so slight in any case that it was of little importance.

TABLE V.—RESULTS WITH BALDWIN AT GRAND LEDGE, 1918.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Standard Lime-Sulphur Solution	9	5	1852	94.38	0.32	0.54	4.75
		6	2644	93.04	1.62	0.64	4.69
Totals			4496	93.59	1.09	0.60	4.71
Dry Lime-Sulphur, 3 in 50	9	7	1989	92.11	1.91	0.85	5.13
		8	3100	94.26	2.16	0.55	3.03
Totals			5089	93.42	2.06	0.67	3.85
Dry Lime-Sulphur, 5½ in 50	10	9	1689	93.72	1.18	0.77	4.32
		10	2583	95.97	0.97	0.54	2.52
Totals			4272	95.08	1.05	0.63	3.23
Check	1	C	2116	68.71	7.28	15.93	8.08

Scab Control. The amount of scab on the check tree was so small that no comparison could be made as to the fungicidal value of the different materials. Counts were made on the fruit from two trees in each sprayed plot and from the check tree. The tabulated results of the counts are shown in Table V.

CALCIUM ARSENATE ON BEN DAVIS

Materials. Rex calcium arsenate was used on a small block of Ben Davis to determine its effect on the foliage and its insecticidal value.

FIG. 4. CALCIUM ARSENATE injury on Ben Davis foliage. Defoliation was severe.

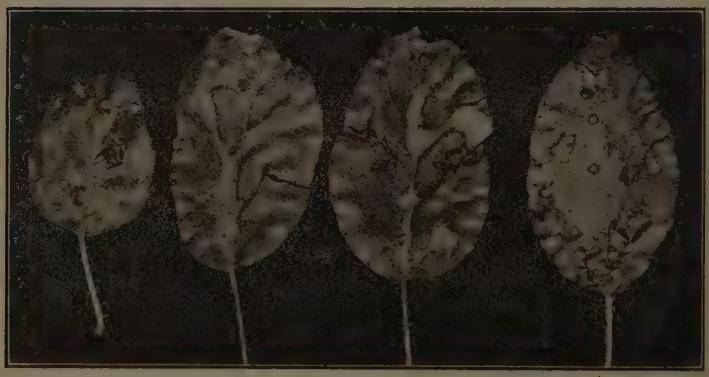


FIG. 5. MAGNESIUM ARSENATE injury on foliage of apple.

For comparison, one plot was sprayed with lead arsenate. Check trees were left. The materials were used as follows:

Plot 4. Calcium arsenate (dry), 1 lb. in 50 (no lime).

Plot 5. Lead arsenate (dry), 1¼ lb. in 50.

They were both used in combination with lime-sulphur diluted at the rate of 1 to 40. The arrangement of the trees and plots is shown in Chart IV.

Applications. The four regular applications were made as follows:

1st. Cluster or pink application.
2nd. Calyx application.
3rd. Two weeks after the second.
4th. First week in August.

All spraying was done with a spray gun and with high pressure.

RESULTS

Foliage Injury. The trees sprayed with *lead arsenate* were in good condition. There was very little foliage injury. The foliage of trees sprayed with *calcium arsenate* was severely burned. The leaves were badly spotted and many leaves dropped. The injury was not of the yellow-leaf type.

TABLE VI.—RESULTS WITH BEN DAVIS AT GRAND LEDGE, 1918.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Lead Arsenate with Lime-Sulphur	11	1	3093	90.33	6.24	2.36	1.07
		2	1072	97.20	1.21	0.56	1.03
Totals			4165	96.15	1.16	0.83	1.86
Calcium Arsenate with Lime-Sulphur	13	3	2730	95.13	1.65	0.66	2.56
		4	1837	97.66	0.43	1.09	0.82
Totals			4567	96.15	1.16	1.86	0.83
Check	1	C	2060	38.13	13.49	46.84	3.34

Insect Control. Both materials gave very good insect control. 46.8% of the apples on the unsprayed tree were affected by codling moth. This gave a good check on the insecticidal value of the different materials. The results of counts are given in Table VI.

EXPERIMENTS IN 1919

The work with apples in 1919 was done in two orchards near Grand Rapids. The work consisted of a comparison of dusting with spraying and testing several dry lime-sulphurs and some of the newer arsenicals.

A TEST OF SULPHUR DUSTS LIME-SULPHUR SOLUTIONS

DRY LIME-SULPHURS AND B. T. S.

A Duchess orchard of about 125 trees was used for experimental tests

with sulphur dust, lime-sulphur, Sherwin-Williams dry lime-sulphur, Dow dry lime-sulphur and B. T. S. The dry lime-sulphurs and B. T. S. are not applied as a dust, but are dissolved in water and applied as any other spraying material. This orchard is about fifteen years old and is on the fruit farm belonging to Mr. J. C. Maynard. It is located about two miles west of Grand Rapids. There is a number of Wealthy trees in the orchard but they were not used for experimental purposes.

Materials. The orchard was divided into eight plots as shown in Chart V. The plots were treated as follows:

Plot 1. Dusted. 3 in 1 and 90-10 mixtures.
Plot 2. Sprayed. Lime-sulphur solution 1 to 40.
Plot 3. Sprayed. Sherwin-Williams dry lime-sulphur, 3 lbs. in 50.
Plot 4. Sprayed. Sherwin-Williams dry lime-sulphur, 5½ in 50.
Plot 5. Sprayed. Dow dry lime-sulphur, 3 lbs. in 50.
Plot 6. Sprayed. Dow dry lime-sulphur, 5½ lbs. in 50.
Plot 7. Sprayed. B. T. S., 4 lbs. in 50.*
Plot 8. Sprayed. B. T. S., 7 lbs. in 50.

Lead arsenate (dry) at the rate of 1¼ pounds in 50 gallons was used with all spraying materials for all applications. Black Leaf 40 was used on all sprayed plots for the first application.

The dry lime-sulphurs and B. T. S. were used at two rates. First, at the maximum rate recommended by the manufacturers for summer sprayed of apples, and second, at the strength which gives about the same amount of actual sulphur as is contained in one and one-fourth gallons of lime-sulphur solution, testing 32 degrees Beaume. The reason for using these materials at the increased strength has been stated on page 13.

Applications. Three applications were made. The August application was omitted as the fruit was nearly ripe at that time. They were made at the periods listed below:

1st. Cluster or pink application.
2nd. Calyx application.
3rd. Two weeks after second.

The dusting was done with a large power duster. Dusting material was always applied from two directions. The foliage was usually dry when the work was done. The 3 in 1 mixture was used for the first application and the 90-10 mixture was used for the second and third. The spraying was done with spray guns and when the foliage was dry.

RESULTS

Foliage Injury. The foliage of the *dusted* trees was in excellent physical condition. Early in the season a little scab was found but this did not develop further. All *sprayed* trees showed a small amount of foliage injury and the leaves did not have the same clean, bright appearance as on dusted trees. The injury was not severe. There was no noticeable difference in the amount of injury in the different sprayed plots.

*B. T. S. is manufactured by the General Chemical Company. The letters are the initials of the words "barium tetra-sulphide." This is the chemical name of the material.

Plot 1.

W	S	D	S		D		S		D
S		D		D		D		W	
	D		2		D		3		D
W		D		D		D		W	
	S		I		D		D		3
W		D		D		D		S	
	D		D		D		D		D
W		D		D			W		
	S		D		D		S		S
S		D		D		S		W	
	4		D		D		D		S
W		D		D		D		W	
	D		D		D		D		D
W		D		D		S		W	
	D		D		D		D		D
W		S		D		D		W	
	D	D	S		D		D		D
W	D			S		W		W	
	S	D	S	D	S		S	W	D
W		D		D					S
	5		D		D		D	W	
W		D		D		W			D
	15		17		D		12	W	
W		D	D	9		D		W	D
	S		S		D		13		S
W		14		D		D		S	D
	S	D	D		10		C	W	S
W		D		8		D		S	
	D	D	7		D		S		D
W		D	D	D		D	S	D	
	D	D	D		11	D	S		D
W	D	6	D	D		D		S	
W	D	S		D	S		16		D
W	D	D	S	D	S	D	S		
Plot	2	3	4	5	6	7	8		

CHART V. Diagram showing arrangement of trees and plots in the Maynard orchard at Grand Rapids. D, Duchess; C, check; W, Wealthy; S, small tree. Numbers indicate count trees. Tree 16 is a check tree. The plots are indicated by the numbers at the top and bottom of the chart.

Plot 1. Dusted.
Plot 2. Dilute lime-sulphur.
Plot 3. Sherwin-Williams dry lime-sulphur, 3 in 50.
Plot 4. Sherwin-Williams dry lime-sulphur, 5¾ in 50.
Plot 5. Dow dry lime-sulphur, 3 in 50.
Plot 6. Dow dry lime-sulphur, 5½ in 50.
Plot 7. B. T. S. 4 in 50.
Plot 8. B. T. S. 7 in 50.

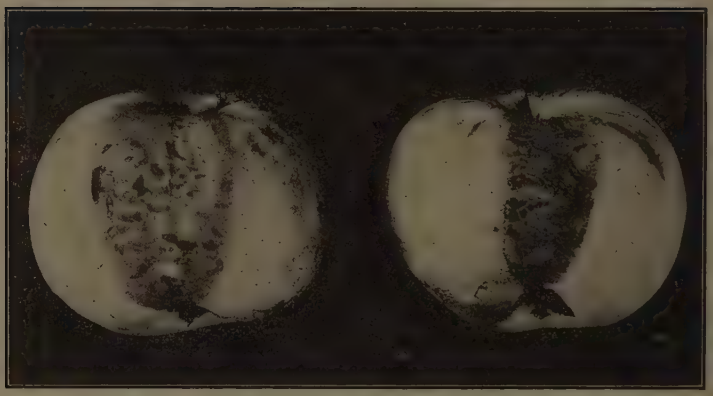


FIG. 6. FROST INJURY. This injury on Duchess was caused by a severe freeze before the blossoms were open.

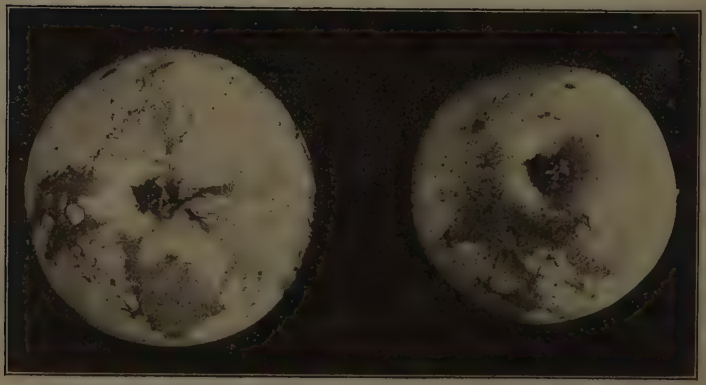


FIG. 7. SPRAY INJURY. This injury on Duchess was caused by sulphur sprays.

Injury to Fruit. There was a slight russeting found on the fruit from most sprayed trees. This was more noticeable where B. T. S. was used. The fruit from dusted trees was very smooth. Frost injury was found throughout the orchard. This was entirely different from the russeting just mentioned.

Insect Control. There was so little aphis injury on the check that no comparison can be made. *Dusting* and *spraying* both gave very good control of codling moth and other chewing insects. The amount of injury on the *check* trees was not very severe, but there was enough for a check on the different materials.

Scab Control. Sulphur dust and *lime-sulphur solution* gave about equal control of scab. Control in those plots was nearly complete except for an early infection which took place before any dusting or spraying was done. Dusting gave more uniform control than spraying.

The *dry lime-sulphurs* and *B. T. S.* failed in every case to give satisfactory control of scab. The increase in strength of these materials gave very little benefit.

The tabulated results of all counts made are shown in Table VII. In this table no results are given for the plot sprayed with B. T. S. at the rate of 4 pounds in 50 gallons. The row which was sprayed with this material had several Wealthy trees in it and the Duchess trees that were there did not produce full crops, so no counts could be made.

TABLE VII.—RESULTS WITH DUCHESS AT GRAND RAPIDS, 1919.

Treatment.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Aphis Per cent.	Codling. Per cent.	Other Insects. Per cent.
Dusted	22	1	1698	86.63	12.77	0.11	0	0.47
		2	3219	86.70	13.11	0	0	0.19
		3	1268	88.17	11.27	0	0	0.55
Totals			6185	86.98	12.64	0.03	0	0.34
Lime-Sulphur, 1 to 40	11	4	1320	91.13	8.64	0	0.07	0.15
		5	2046	79.81	19.16	0.10	0.10	0.83
		15	1956	84.15	15.44	0	0.05	0.36
Totals			5322	84.22	15.18	0.04	0.07	0.49
Sherwin-Williams Dry L-S, 3 in 50	17	6	1184	64.10	33.44	0.51	0	2.03
		14	1050	70.19	29.33	0	0.19	0.28
Totals			2234	66.96	31.51	0.27	0.09	1.21
Sherwin-Williams Dry L-S, 5½ in 50	12	7	1133	71.05	27.54	0	0.18	1.23
		17	667	85.00	14.84	0	0.15	0
Totals			1800	76.22	22.83	0	0.16	0.78
Dow Dry L-S, 3 in 50	15	8	3214	60.42	38.52	0	0.09	0.96
		9	3482	61.57	37.33	0	0.08	1.01
Totals			6696	61.02	37.90	0	0.09	0.98
Dow Dry L-S, 5½ in 50	11	10	1773	63.06	36.60	0	0	0.33
		11	2146	64.54	34.29	0	0.19	0.97
Totals			3919	63.87	35.34	0	.10	0.69
B. T. S., 7 in 50	7	12	1708	78.81	20.43	0	0	0.76
		13	1018	64.93	34.77	0	0	0.29
Totals			2726	73.62	25.79	0	0	0.59
Check	2	16	1153	21.59	62.36	3.72	9.97	27.67

FIG. 8. APPLE BLOSSOM BUDS. This shows the stage of development of the buds when the "pink" or "cluster" application is usually made.

FIG. 9. APPLE BLOSSOM BUDS. If the buds remain in this stage for several days because of cold weather and conditions are favorable for scab development, an extra application will probably be profitable. It should be followed by the regular cluster application.

In comparing the percentages of scabby fruit on any of the plots it will be well to consider the following facts. In the spring the blossom buds opened slightly, just enough so that the individual buds could be easily distinguished, and remained in this condition for a week or more because of cold weather. During this period conditions were very favorable for scab development. No dusting or spraying was done until the buds had separated into the cluster stage.

When the fruit was harvested and counted, there was found on the apples from all plots an early infection of scab. This scab was in small spots which were on or partly on the calyx lobes. On fruit from the dusted plot there was very little scab of any later infection. On fruit from the plot sprayed with lime-sulphur solution there was a small amount of scab on other parts of the apples. In all the dry lime-sulphur and B. T. S. plots there was much more on other parts of the apples. The later infections had nearly always developed with larger spots.

This early infection undoubtedly occurred before the first application was made. On the plots treated with sulphur dust and lime-sulphur solution there was very little scab of any later infection. This condition indicates two things: (1) an early or "pre-pink" application would have prevented the early infection of scab and (2) sulphur dust and lime-sulphur solution prevented practically all development of later infections but the dry lime-sulphur and B. T. S. did not.

A TEST OF SEVERAL ARSENATES ON APPLES

A block of mature Stark trees was used for testing several arsenates. This block of Stark trees is part of an orchard of several varieties belonging to Mr. A. D. O'Brien and is located about three miles west of Grand Rapids.

Materials. The block of trees was divided into four plots of about nine trees each and each plot was sprayed with a different poison. The materials and the strengths at which they were used are listed here:

Plot 1. Corona calcium arsenate (dry), 1 lb. in 50 gal. with 3 lbs. hydrated lime added.
Plot 2. Corona lead arsenate (dry), 1¼ lbs. in 50 gal.
Plot 3. Dow magnesium arsenate (dry), 1¼ lbs. in 50 gal.
Plot 4. NuRexform lead arsenate (dry), 1¼ lbs. in 50 gal.
Two trees were left unsprayed as checks.

Lime-sulphur solution, diluted at the rate of 1 to 40, was used in combination with all the poisons, for all applications. Black Leaf 40 was used on all plots for the first application. The arrangement of the trees and plots is shown in Chart VI.

Applications. Four applications were made according to the regular schedule.

1st. The pink or cluster application.
2nd. Immediately after petals had fallen.
3rd. Two weeks after second.
4th. July 30th.

All spraying was done with a spray gun and with 200 to 225 pounds pressure.

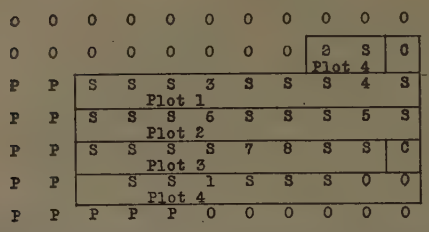


CHART VI. Diagram showing arrangement of trees and plots in the O'Brien orchard at Grand Rapids. S, Stark; C, check; O, other varieties; P, peach tree. Numbers indicate count trees. Plot 4 is in two parts. Plot 1, calcium arsenate; Plot 2, Corona lead arsenate; Plot 3, Magnesium arsenate; Plot 4, Nurexform lead arsenate. The check tree next to the small portion of Plot 4 was used as a count tree.

RESULTS

Foliage Injury. The foliage of all trees sprayed with *lead arsenate*, both Corona and NuRexform, was in very good condition throughout the season. There was very little injury which was traceable to lead arsenate.

The trees sprayed with *calcium arsenate* showed foliage injury but not enough to be classed as serious.

Magnesium arsenate caused very severe foliage injury. This was not evident until after the calyx application. In a few days after this application, many leaves were spotted, turned yellow and dropped. The effects of the injury caused by the calyx application had about passed when the third application was made. The same process of leaves turning yellow and dropping developed again and continued for about two weeks. The same thing happened again after the fourth application. These trees lost fully half their foliage because of the injury by magnesium arsenate.

TABLE VIII.—RESULTS ON STARK AT GRAND RAPIDS, 1919.

Material.	No. of Trees in Plot.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Codling. Per cent.	Other Insects. Per cent.
Corona Lead Arsenate	9	5	3765	97.90	1.56	.53
		6	2676	96.45	2.72	.82
Totals			6441	97.30	2.04	.65
NuRexform Lead Arsenate	7	2	4136	97 97	1.81	.21
		1	3159	97 06	2.37	.56
Totals			7295	97.57	2.05	.37
Corona Calcium Arsenate	9	3	2313	94.38	5 44	.17
		4	3553	93 55	5 43	1.01
Totals			5866	93 88	5 43	.68
Dow Magnesium Arsenate	8	7	1698	85.22	12 01	2.76
		8	2517	87.48	11.32	1.19
Totals			4215	86 58	11.60	1.82
Check	2	C	2284	15 53	81.17	3.45

Insect Control. Both kinds of lead arsenate controlled all insects very satisfactorily. *Calcium arsenate* did not give quite so good control as lead arsenate. *Magnesium arsenate* failed to give satisfactory insect control.

The tabulated results of counts made are given in Table VIII.

SUMMARY OF RESULTS OF EXPERIMENTS WITH APPLES

DUSTING

Scab Control. In 1918 at Morrice the amount of scab that developed on the untreated trees was not very great, but with Stark there was enough to give a satisfactory check on different materials used. The dusting method gave almost complete control of scab, as there was only 1.9% of scabby-apples in the dusted plot of Stark. With Baldwin there was only 1.1% of scabby apples on the check tree, so the results with this variety are not conclusive.

At Muir in 1918 with Northern Spy there was so little development of scab on the check tree that no comparison can be made of dusting with spraying.

At Belding in 1918 with Baldwin there was enough development of scab on the check to allow satisfactory comparisons. The dusting method gave nearly complete control of scab and better control than spraying with lime-sulphur solution. Failure of the sprayer to always work satisfactorily probably accounts for part of the scab on the sprayed plot.

In 1919 at Grand Rapids dusting gave better control of scab on Duchess than spraying with lime-sulphur solution. The difference, however, was very small.

Insect Control. In part of the experiments there was so little insect injury on the check trees that no safe comparisons can be made. This is true of the work in 1918 with Baldwin at Morrice and Belding and with Northern Spy at Muir. With Stark at Morrice there was considerable injury by codling moth on the check tree, but dusting gave nearly complete control. In 1919 at Grand Rapids dusting controlled all chewing insects very satisfactorily.

Foliage Injury. The foliage on dusted trees has been in better physical condition in every experiment than where the trees were sprayed. In some cases there has been some development of scab on the foliage of dusted trees, but this has never been severe.

DRY LIME-SULPHURS AND B. T. S.

Scab Control. The work with Sherwin-Williams dry lime-sulphur at Grand Ledge gave no conclusive results, as there was so little scab on the check tree. At Grand Rapids in 1919 the work with Duchess gave definite results. Sherwin-Williams and Dow dry lime-sulphurs and B. T. S. all failed to give satisfactory control of scab. The strength at which these materials were used made little difference in the results.

They were compared with standard lime-sulphur solution, 1 to 40, which gave better results than any of the substitutes.

ARSENICALS

Calcium Arsenate. In 1918 calcium arsenate was used in three orchards including Stark, Baldwin, Ben Davis and Northern Spy. It was used with dilute lime-sulphur and without the addition of lime. It caused rather severe foliage injury on Ben Davis, considerable injury on Northern Spy and slight injury on Stark and Baldwin. Codling moth injury was quite severe on the check trees of Ben Davis and Stark but where calcium arsenate was used the control was very good.

In 1919 calcium arsenate was used on Stark. Lime was added to prevent burning. It caused less injury than when used without lime but the control of codling moth was not so good as in 1918.

Magnesium Arsenate. This material was used on Stark and the results were very unsatisfactory. Foliage injury was very severe and the insect control was not satisfactory.

Lead Arsenate. This material has given uniformly good results wherever used. There has been very little foliage injury and insect control has been satisfactory. Corona dry lead arsenate has been used in nearly all the experimental work reported in this bulletin. NuRexform brand was also used in 1919 and it gave satisfactory results.

Table IX summarizes the results of the counts for each plot in the various experiments.

TABLE IX.—SUMMARY OF RESULTS OF DUSTING AND SPRAYING EXPERIMENTS WITH APPLES.

Year.	Variety and Location.	Treatment.	Count Tree Number.	Total No. Apples.	Sound. Per cent.	Scab. Per cent.	Codling. Per cent.	Other Insects. Per cent.
1918	Baldwin at Morrice	Dusted	3	12115	98.1	0.7	0	1.0
		L-S and Cal. Ars.	3	9462	95.2	0.9	0	3.8
		L-S and Ld. Ars.	3	13354	95.0	1.1	0	3.8
		Check	1	2282	87.4	1.1	3.8	7.5
	Stark at Morrice	Dusted	3	9885	97.5	1.9	0.01	0.6
		L-S and Cal. Ars.	3	7819	95.1	2.5	0.07	2.2
		L-S and Ld. Ars.	3	7461	92.8	5.3	0.2	1.6
		Check	1	1229	52.3	16.4	27.5	5.4
	Baldwin at Belding	Dusted	4	6371	96.8	1.7	0.3	1.1
		Sprayed	4	5252	90.6	8.3	6	1.0
		Check	1	1324	62.0	36.0	0.5	1.3
	Spy at Muir	Dusted	2	2104	95.3	1.8	0.2	0.1
		L-S and Cal. Ars.	2	2562	96.0	1.2	0	0.1
		L-S and Ld. Ars.	2	3656	94.6	0.7	0.02	0.05
		Check	1	540	88.3	5.9	0	0.1
	Baldwin at Grand Ledge	L-S	2	4496	93.5	1.0	0.6	4.7
		S-W Dry L-S, 3 in 50	2	5089	93.4	2.0	0.6	3.8
		S-W Dry L-S, 5½ in 50	2	4272	95.0	1.0	0.6	3.0
		Check	1	2116	68.7	7.2	15.9	8.0
	Ben Davis at Grand Ledge	L-S and Cal. Ars.	2	4567	96.1	1.1	0.8	1.8
		L-S. and Ld. Ars.	2	4165	92.1	4.9	1.8	1.0
		Check	1	2060	38.1	13.4	46.8	3.3
1919	Duchess at Grand Rapids	Dusted	3	6185	86.9	12.6	0	0.3
		L-S	3	5322	84.2	15.1	0.07	0.4
		S-W Dry L-S, 3 in 50	2	2234	66.9	31.5	0.09	1.2
		S-W Dry L-S, 5½ in 50	2	1800	76.2	22.8	0.16	0.7
		Dow Dry L-S, 3 in 50	2	6696	61.0	37.9	0.09	0.9
		Dow Dry L-S, 50½ in 5	2	3919	63.8	35.3	0.10	0.6
		B. T. S., 7 in 50	2	2726	73.6	25.7	0	0.5
		Check	1	1153	21.5	62.3	9.9	27.6
	Stark at Grand Rapids	Corona Ld. Ars.	2	6441	97.3	.....	2.0	0.6
		NuRexform Ld. Ars.	2	7295	97.5	.....	2.0	0.3
		Corona Cal. Ars.	2	5866	93.8	.....	5.4	0.6
		Dow Mag. Ars.	2	4215	86.5	.....	11.6	1.8
		Check	1	2284	15.5	.....	81.1	3.4

Key to abbreviations:
L-S—Dilute lime-sulphur.
S-W. Dry L-S—Sherwin-Williams Dry lime-sulphur.
Dow Dry L-S—Dow Dry lime-sulphur.
B. T. S.—B. T. S.
Ld. Ars.—Lead arsenate.
Cal. Ars.—Calcium arsenate.
Mag. Ars.—Magnesium arsenate.

EXPERIMENTS WITH CHERRIES AND PLUMS

The work with cherries and plums has consisted of comparisons of the dusting and spraying methods of application and testing calcium and magnesium arsenates in comparison with lead arsenate.

EXPERIMENTS IN 1918

CALCIUM ARSENATE ON CHERRIES AND PLUMS

Blocks of Moore's Arctic plum and Early Richmond cherry on the Horticultural grounds at East Lansing were used for making a comparison of calcium arsenate with lead arsenate. The effect on the foliage was the main point of consideration.

Materials. The materials were used as follows:

1st. Calcium arsenate (dry), 1 lb. in 50 gal. No lime.
2nd. Lead arsenate (dry), 1¼ lb. in 50 gal.

They were used in combination with lime-sulphur solution, diluted at the rate of 1 to 40. All spraying was done with a spray gun and with high pressure. Each material was used on a plot of from seven to nine trees of each kind of fruit. Check plots of equal size of each kind of fruit were left unsprayed.

Applications. Three applications were made on the plums and two on the cherries. The first one was not made on the cherries. They were as follows:

1st. Just before blossoms opened.
2nd. Soon after the petals had fallen.
3rd. About two weeks after second.

RESULTS

The foliage of all trees was in excellent condition throughout the season. There was no injury that could be traced to spraying material.

DUSTING JAPANESE PLUMS

A planting of mixed varieties of plums on the College grounds at East Lansing was dusted in 1918. There were several species and several varieties of each species, including European, Japanese and native species. Since Japanese varieties are very subject to injury by several spraying materials, they were dusted to determine if such treatment would have any ill effects on the foliage. No check plot was left untreated nor was any other material used.

Material. A 90-10 mixture of sulphur and lead arsenate and pure sulphur were used.

Applications. Four applications were made as follows:

1st. Just before blossoms opened.
2nd. Just after the petals had fallen.
3rd. Two weeks after second.
4th. About one month before fruit was ripe.

The 90-10 mixture was used for the first three applications and sulphur only for the fourth.

RESULTS

The dusting materials caused no injury at any time on the Japanese varieties. The trees of the native and European varieties were also free from injury.

EXPERIMENTS IN 1919

A COMPARATIVE TEST OF ARSENICALS ON PLUMS

An orchard of plums on the College grounds at East Lansing, which contains blocks of Lombard, Shropshire Damson, and Moore's Arctic, was used for a comparative test of several arsenates. There were five rows of trees in this experiment and each row constituted a plot and contained trees of each of the varieties. A different arsenate was used on each row. Check trees of each variety were left unsprayed.

Materials. The arsenates used are listed below:

1st. Corona dry lead arsenate, 1¼ lbs. in 50 gal.
2nd. Corona calcium arsenate, 1 lb. in 50 gal. (lime added).
3rd. Dow magnesium arsenate, 1¼ lbs. in 50 gal.
4th. NuRexform lead arsenate, 1¼ lbs. in 50 gal.
5th. Rex calcium arsenate, 1 lb. in 50 gal. (lime added).

They were all used in combination with lime-sulphur diluted at the rate of 1 to 40.

Applications. Three applications were made as follows:

1st. Just before the blossoms opened.
2nd. Soon after the petals had fallen.
3rd. Two weeks after second.

All spraying was done with a spray gun.

RESULTS.

There was considerable foliage injury in all plots especially after the third application, but most of this was lime-sulphur injury as the temperature was quite high at that time. There was some injury which probably was arsenical injury but it was not severe and was not confined to any one plot. The foliage of the unsprayed trees was in excellent condition. Lombard seemed more susceptible to injury by spraying materials than the other varieties.

DUSTING AND SPRAYING CHERRIES AND PLUMS AT GRAND RAPIDS

On the farm of Mr. J. C. Maynard, near Grand Rapids, comparative tests were made with sulphur dust, lime-sulphur solution and bordeaux

on Lombard plums and Montmorency cherries. Rather large plots were treated with each of the materials. No details of the experiment will be given as there was no development of insect or fungus trouble on the check trees of either fruit.

The trees in the *bordeaux* plot of each kind of fruit showed severe foliage injury. It was of the yellow leaf type and caused heavy defoliation. This was probably due to peculiar weather conditions which were very favorable to the development of such injury. There was a little *lime-sulphur* injury on both cherries and plums after one of the applications made during hot weather. The foliage of all *dusted* trees was in excellent condition.

DUSTING CHERRIES TO CONTROL SHOT-HOLE FUNGUS AT EAST LANSING

A block of eighty trees of Montmorency and English Morello on the College grounds at East Lansing was used for a comparative test of the dusting and spraying methods for the control of shot-hole fungus or leaf blight.* The trees are ten years old.

Materials. The orchard was divided into two plots so that each plot contained trees of both varieties. The arrangement of the trees and plots is shown in Chart VII. The materials were used as follows:

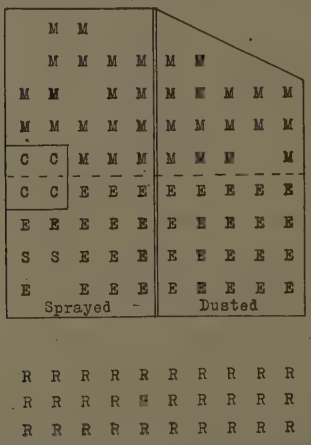


CHART VII. Diagram showing arrangement of trees and plots in cherry orchard at East Lansing. E, English Morello; M, Montmorency; C, check; S, small tree; R, raspberries.

Plot 1. Dusted. 90-10 mixture except for the last application when sulphur alone was used.

Plot 2. Lime-sulphur, 1 to 40. Lead arsenate was used when necessary.

Plot 3. Check. Untreated.

*Shot-hole fungus is caused by *Coccomyces hiemalis* Higgins. It is also known as leaf-blight, leaf-spot and yellow leaf.

FIG. 10. CONIOTHYRIUM ON SOUR CHERRY. The cherries hang onto the trees after the leaves have fallen. This is a close view of several clusters of diseased cherries. Variety is English Morello. Photo. Nov. 20, 1919.

FIG. 11. CONIOTHYRIUM ON SOUR CHERRY. This shows the large number of cherries affected by this disease.

Applications. Four applications as follows were made:

1st. Just before blossoms opened.
2nd. Soon after petals had fallen.
3rd. Two weeks after second application.
4th. After fruit was harvested.

All spraying was done with a spray gun. The dusting material was applied early in the morning when the trees were wet with dew. An Ideal power duster was used.

RESULTS

Montmorency. There was so little development of leaf blight on the Montmorency check trees that no comparison can be made of the two materials.

English Morello. Leaf blight developed on the *check* trees of English Morello soon after the fruit was harvested. This was about July 15.

FIG. 12. CANE BLIGHT ON BLACK RASPBERRIES. This disease is caused by *Coniothyrium Fuckelii*. It frequently causes the fruiting canes to die before the fruit is mature.

It developed steadily until by September 1 the trees were practically defoliated.

On *dusted* trees the disease was evident early in August and by the middle of September many of the trees were badly defoliated.

Sprayed trees showed no evidence of leaf-blight until late in September and then the development was only very slight.

Coniothyrium on Cherries. When the fruit was being harvested it was noticed that many Morello cherries were drying up and hanging onto the trees. Some had nothing left but the pit covered with the dry cherry skin; some were partly dry and others were in just a slightly wrinkled condition. It was found that around the base of the stem of all affected fruits there was a cankered area which apparently had girdled the stem so that the sap supply was shut off. None of this trouble was found on Montmorency trees.

FIG. 13. CONIOTHYRIUM ON SOUR CHERRY. A small branch from an English Morello tree affected by Coniothyrium. Photo July 15, 1919.

All the affected cherries hung tightly to the tree throughout the summer and were still there in December.

The trouble was found to be caused by a species of Coniothyrium and might have come from a planting of black raspberries which stood just south of the cherry orchard.

There was considerable cane-blight in the berries which is caused by a fungus known as Coniothyrium Fuckelii.*

Control of Coniothyrium on Cherries. All trees in the *dusted* plot which bore fruit had cherries affected by this trouble. No affected

*The fungus on the cherries was identified by Ray Nelson of the Botanical Department.

cherries were found on trees *sprayed* with *lime-sulphur*. This indicates very strongly that dilute lime-sulphur will prevent the first or primary infection of this disease and that sulphur dust will not. No statement can be made at this time regarding the control of this disease after it has become established in the trees. Cane-blight is frequently found on black raspberries so it will be well not to plant them as an intercrop in cherry orchards or in close proximity to them.

SUMMARY OF RESULTS OF EXPERIMENTS WITH CHERRIES AND PLUMS

Foliage Injury by Arsenicals. In 1918 Moore's Arctic plums and Early Richmond cherries were sprayed with calcium arsenate in combination with dilute lime-sulphur. Lead arsenate was also used for comparison. Neither material caused any injury on either cherries or plums.

In 1919 Lombard, Shropshire Damson and Moore's Arctic plums were sprayed with Corona dry lead arsenate, Corona calcium arsenate, Dow magnesium arsenate, rex calsium arsenate and Nu Rexform lead arsenate. These materials were used in combination with lime-sulphur. There was considerable foliage injury on all sprayed trees but it was of the type of injury frequently found when lime-sulphur is used during hot weather. The temperature was high when part of this spraying was done. There was some arsenical injury but it was not confined to the trees sprayed with any one material.

These results indicate that sour cherries and plums (not including Japanese varieties) are not so susceptible to arsenical injury to the foliage as some other fruits.

Dusting Japanese Plums. Trees of several varieties of Japanese plums were dusted during the season of 1918 to determine if the foliage would be injured in any way by dusting material composed of sulphur and lead arsenate. There was no injury at any time to the Japanese varieties nor was the foliage of several varieties of native plums injured.

Dusting and Spraying Cherries at the College. An orchard of Montmorency and English Morello cherries was used for a comparative test of spraying with dilute lime-sulphur and dusting with sulphur dust for the control of shot-hole fungus. The work with Montmorency gave no conclusive results as no disease developed on the check trees. The work with Morello, however, gave definite results. Dilute lime-sulphur controlled shot-hole fungus satisfactorily. Dusting did not control it.

In the dusted plot a disease caused by Coniothyrium developed seriously but there was none of it on trees sprayed with dilute lime-sulphur.

EXPERIMENTS WITH PEACHES

The experimental work with peaches was all done in 1919. There were three separate experiments. One at Saugatuck for the control of leaf-curl by dusting, one at Grand Rapids comparing dilute and concentrated dusts with self boiled lime-sulphur and lead arsenate and the third at Grand Rapids as a test of magnesium arsenate in comparison with lead arsenate.

DUSTING TO CONTROL PEACH LEAF CURL

A test was made to determine if leaf curl can be controlled by the dusting method. This work was done in the orchard belonging to Mr. Jas. Boyce which is located about one mile from Lake Michigan and five miles north of Saugatuck. The variety was New Prolific. The trees were four years old.

Materials. About fifty trees were used for the experiment. They were divided into two plots and treated as follows:

Plot 1. Niagara Soluble Sulphur (for dusting).
Plot 2. 90-10 mixture of sulphur and lead arsenate.

Several trees were left untreated as checks. The lead arsenate in the 90-10 mixture was probably of no value except as a sticker. It would not have been used had any other mixture been available at that time.

Spraying. The main part of the orchard was sprayed by Mr. Boyce with Sherwin-Williams dry lime-sulphur. This material had been held over from 1918 and was used at double the strength recommended by the manufacturers because it apparently had deteriorated in quality.

Application. The dusting was done on March 7. The material was applied very liberally and from two directions. The spraying was done late in March. There were several days of quite warm weather soon after the dusting work was done and the buds undoubtedly swelled enough to allow an infection of leaf curl.

RESULTS.

The leaf-curl injury was very severe in this orchard as weather conditions were ideal for its development. The condition of the trees early in June in the several plots was as follows:

Check trees. The untreated trees were practically defoliated except for some new terminal growth.

Dusted. 90-10 mixture. Trees dusted with this mixture were in only slightly better condition than the check trees.

Dusted. Niagara Soluble Sulphur. The trees in this plot were in a slightly better condition than those dusted with the 90-10 mixture. The difference, however, was only very small.

Sprayed. The development of leaf-curl on the sprayed trees was severe, but the condition was much better than that of the dusted trees. The failure to control the disease on the sprayed trees was probably due to two factors: First, the warm weather before the spraying was done, and, second, the material used possibly was not effective. No definite tests have been made with dry lime-sulphur to control leaf-curl but since it has not given satisfactory control of apple scab it is doubtful if it would control leaf-curl.

MAGNESIUM ARSENATE ON PEACHES

A block of Early Michigan peaches on the Graham Experiment Station farm at Grand Rapids was used for testing magnesium arsenate. For comparison, one plot was sprayed with lead arsenate and another left unsprayed.

Materials. The block of trees was divided into four plots of from fifteen to twenty-five trees each and treated as follows:

Plot 1. Check. Unsprayed.
Plot 2. Corona dry lead arsenate. 1 lb. in 50 gal. and 3 lbs. hydrated lime added to each 50 gal.
Plot 3. Dow magnesium arsenate. 1 lb. in 50 gal. No lime added.
Plot 4. Dow magnesium arsenate. 1 lb. in 50 gal. and 3 lbs. lime added to each 50 gal.

The materials were used as listed above for the first application. For the second application Plots 2, 3 and 4 were all sprayed with self-boiled lime-sulphur and the poisons were used in combination with it.

Applications. Two applications were made:—

1st. As the last of the "shucks" were falling.
2nd. Two weeks after the first.

The spraying was done under high pressure and with a spray gun.

RESULTS

Check plot. The foliage of the trees in this plot was in excellent condition throughout the season.

Lead arsenate plot. The foliage of all trees in this plot was in very good condition. There was practically no injury; only an occasional small spot could be found. There was no loss of leaves from these trees. The condition was the same after both applications.

Magnesium arsenate. No lime added. Within two or three days after the first application the foliage began dropping. Practically every leaf showed injury and defoliation was very severe. Many small limbs were entirely defoliated so that the limb died and the fruid dried up.

Magnesium arsenate. Lime added. The effect upon the trees in this plot was much the same as where no lime was used but the injury was not so severe.

Magnesium arsenate with self-boiled lime-sulphur. The effect of this combination was about the same as when used with lime.

The combined effect of two applications on Plot 3 resulted in almost

complete defoliation. On many trees, after the effects of the magnesium arsenate had passed, the only foliage left was the new growth that had developed after the spraying.

In Plot 4 the total injury was not so great and resulted in less permanent injury to the trees.

A COMPARISON OF DILUTE AND CONCENTRATED DUST MIXTURES WITH SELF-BOILED LIME-SULPHUR

A block of Crosby peaches on the Graham Experiment Station Farm at Grand Rapids was used for this experiment.

Materials. The block of trees was divided into four plots and treated as follows:

Plot 1. Check; untreated.

Plot 2. Self-boiled lime-sulphur. Lead arsenate added when necessary. Lead arsenate with lime was used for the first application.

Plot 3. Dilute dust. 50-40-10 mixture for two applications and 50-50 mixture for the last.

Plot 4. Concentrated dust. 90-10 mixture for two applications and straight sulphur for the last.

Applications. Three applications were made.

1st. Just as the last of the "shucks" fell.
2nd. Two weeks after first.
3rd. July 30.

The dusting was done with a large power duster and the spraying with a spray gun.

RESULTS

Disease and Insect Control. There was no injury by insects or diseases on the check plots so no conclusions can be drawn regarding their control.

Foliage Injury. There was no foliage injury found at any time in any plot.

Injury to Fruit. There was an occasional peach which was injured by the dusting materials. This was very rare and occurred only when the outlet had been close to the tree and a heavy coating of dusting material was deposited on the fruit. The injury occurred then only when the fruit was exposed directly to the sun. An injured peach is shown in Fig. 14. This type of injury is of little consequence as it does not occur under normal conditions.

SUMMARY OF RESULTS OF EXPERIMENTS WITH PEACHES

Dusting to Control Leaf-Curl. Peach trees were dusted with Niagara Soluble Sulphur (for dusting) and 90-10 mixture of sulphur and lead arsenate. Neither of these materials controlled leaf-curl. The condition of dusted trees was only slightly better than of check trees. The check trees were practically defoliated.

Magnesium Arsenate on Peaches. Magnesium arsenate was used, both with and without lime and with self-boiled lime-sulphur. One plot was sprayed with lead arsenate and there was practically no foliage injury. Magnesium arsenate without lime caused very severe injury and defoliation. Where used with lime or self-boiled lime-sulphur the injury was severe but not so bad as where used alone.

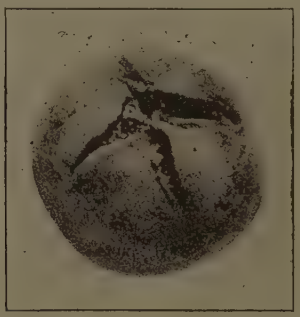


FIG. 14. SULPHUR INJURY ON PEACH. Such injury is occasionally found on dusted trees. It occurs only when a heavy coating of sulphur is deposited on fruit exposed directly to the sun. The skin turns black and cracks open if the injury is severe.

EXPERIMENTS WITH CURRANTS

DUSTING AND SPRAYING EXPERIMENTS WITH CURRANTS

The planting of currants on the Horticultural grounds at East Lansing was used for a test of several fungicides and insecticides. There were two sections of this experiment. One was a comparison of dilute lime-sulphur, bordeaux and sulphur dusts for the control of anthracnose. Anthracnose is caused by a fungus known as Pseudopeziza Ribis. It usually occurs as a leaf-spot. Another leaf-spot known as Septoria leaf-spot is sometimes found and can be controlled by the treatment recommended for anthracnose. The other part of the work was a test of lead arsenate, calcium arsenate and magnesium arsenate, to determine if any of them would cause foliage injury.

This planting contains bushes of several varieties and the experimental plots were arranged so that all varieties would be included in each plot. The arrangement of the plots is shown in Chart VIII.

Materials. The treatment given each plot is shown here.

Plot 1. Dusted. 90-10 mixture and straight sulphur.

Plot 2. Sprayed. Bordeaux. 4-4-50. Lead arsenate was used when necessary.

Plot 3. Sprayed. Lime-sulphur, 1 to 40 and Corona dry lead arsenate, 1 lb. in 50 gal. This plot was included in both sections of the work.

Plot 4. Sprayed. Lime-sulphur, 1 to 40, and Dow magnesium arsenate, 1 lb. in 50 gal.

Plot 5. Check. Unsprayed.

Plot 6. Sprayed. Lime-sulphur, 1 to 40 and Corona calcium arsenate, ¾ lb. in 50 gal., plus 3 lbs. hydrated lime.

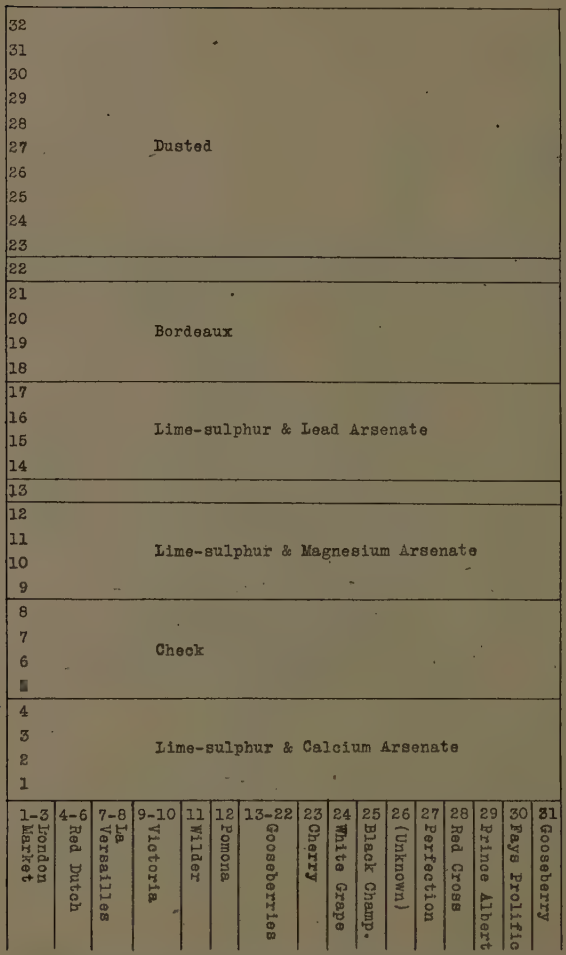


CHART VIII. Diagram showing arrangement of varieties and plots in currant plantation at East Lansing. There are 31 rows with varieties as indicated. Each row has 32 plants. The experimental plots were across the rows so that all varieties were included in each plot.

Applications. Dusting or spraying was done at five different periods as follows:

1st. Just as the leaf buds were opening.
2nd. As the fruit was forming.
3rd. Ten days after second application.
4th. Two weeks after third application.
5th. Soon after fruit was harvested.

The dusted plot only was treated at the fourth application. The fruit was so nearly ripe at that time that any spraying material would have spotted the fruit badly.

No arsenical was used for the third, fourth and fifth applications on the sprayed plots. For the fourth and fifth applications straight sulphur was used on the dusted plot.

RESULTS

Resistance to Disease. There was a great difference in the resistance of the different varieties to anthracnose. A partial list follows. This is based upon the time and severity of disease development on check plants.

Prince Albert—Very resistant.
London Market—Resistant.
Wilder—Susceptible.
Perfection—Susceptible.
Fay's Prolific—Susceptible.
La Versailes—Susceptible.
Cherry—Susceptible.
Red Cross—Susceptible.
Red Dutch—Very susceptible.

Prince Albert was practically free from disease throughout the season. London Market was not so resistant as Prince Albert. It held its foliage quite well until about September 1st, but lost considerable foliage after that time.

Wilder, Perfection, Fay's Prolific, LaVersailles, Cherry and Red Cross were quite susceptible to anthracnose and untreated plants lost their foliage quite early.

Red Dutch was very susceptible and untreated plants were entirely defoliated early in July.

Foliage Injury. The foliage of all plants sprayed with *bordeaux* was in excellent condition throughout the season. There was no physical injury and the leaves were vigorous and dark green in color.

The foliage of *dusted plants* was severely injured by the sulphur. Many plants lost much foliage because of this injury. The remaining leaves were light green in color and not so vigorous as where bordeaux was used.

Dilute *lime-sulphur* produced the same condition as the dusting sulphur. Defoliation was severe and the color of the leaves was not good.

Injury of this nature probably would not be so severe during a cooler season. Sulphur injury usually occurs when the temperature is high. Conditions in a currant plantation are probably favorable to such injury as the plants are low and close together so that there is not much circulation of air.

Disease Control. Bordeaux gave almost complete control of anthracnose on all varieties. Early in the summer when the new growth was developing rapidly there were times when the new leaves were not covred with spraying material. At such times anthracnose developed slightly on the terminal growth but was checked as soon as the next application was made.

The results with *lime-sulphur* and *sulphur dust* were similar. On resistant varieties there was little development of anthracnose but control was not so complete as with bordeaux. On the more susceptible varieties anthracnose caused considerable defoliation. The amount of injury varied with the resistance of the variety. Red Dutch plants in the sulphur plots were nearly defoliated by August 15. This was caused partly by sulphur injury and partly by anthracnose.

Results with Arsenicals. There was no foliage injury which was traceable to either *lead arsenate, calcium arsenate* or *magnesium arsenate.* There was foliage injury in all these plots but it was caused by lime-sulphur and developed some time after the last spray of arsenicals had been applied.

FIG. 15. PRINCE ALBERT CURRANT. A typical plant from the check plot. Very resistant to anthracnose. Photo. Sept. 10, 1919.

FIG. 16. RED DUTCH CURRANT.
(Above) A typical plant from the check plot. This variety is very susceptible to anthracnose. Plants in the check plot were defoliated early in July. Photo. Sept. 10, 1919.
(Below) A typical plant from the boardeaux plot. Bordeaux gave excellent control of anthracnose and caused no foliage injury. Photo. Sept. 10, 1919.

FIG. 17. RED DUTCH CURRANT.
(Above) A typical plant from the lime-sulphur plot.
(Below) A typical plant from the dusted plot.
Neither of these materials gave satisfactory control of anthracnose and both caused severe defoliation. Photos. Sept. 10, 1919.

FIG. 18. LONDON MARKET CURRANT.
(Above) A typical plant from the check plot. This variety is quite resistant to anthracnose. Photo. Sept. 10, 1919.
(Below) A typical plant from the bordeaux plot. Disease control was very good and there was no foliage injury. Photo. Sept. 10, 1919.

FIG. 19. LONDON MARKET CURRANT.
(Above) A typical plant from the lime-sulphur plot.
(Below) A typical plant from the dusted plot.
The results were about the same with both materials. Much of the defoliation was caused by sulphur injury. Photo. Sept. 10, 1919.

FIG. 20. PERFECTION CURRANT.
(Above) A plant from the check plot. This variety is susceptible to anthracnose but not so much so as Red Dutch. Photo. Sept, 10, 1919.
(Below) A plant sprayed with bordeaux. There was no foliage injury and disease control was excellent. Photo. Sept. 10, 1919.

SUMMARY OF RESULTS OF EXPERIMENTS WITH CURRANTS

Disease Resistance. Varieties of currants vary in their resistance to anthracnose. According to observations made in 1919, Prince Albert is very resistant and London Market is resistant. Wilder, Perfection, Fay's Prolific, La Versailles, Cherry and Red Cross may be classed as susceptible and Red Dutch as very susceptible.

Foliage Injury. The foliage of all plants sprayed with bordeaux was in excellent condition at all times. Sulphur dust and dilute lime-sulphur caused severe foliage injury.

Disease Control. Bordeaux gave excellent control of anthracnose on all varieties. Sulphur dust and dilute lime-sulphur did not give satisfactory control, especially with the more susceptible varieties.

Results with Arsenicals. Lead arsenate, calcium arsenate nor magnesium arsenate used in combination with dilute lime-sulphur caused any foliage injury.

Insect Control. As there was no insect injury on the check plants no comparison can be made of the different materials used.

EXPERIMENTS WITH POTATOES

DUSTING POTATOES TO CONTROL THE COLORADO POTATO BEETLE

In 1918 on the Horticultural grounds at East Lansing a comparison was made of the dusting and spraying methods of application of poison for the control of the Colorado potato beetle or "potato bugs" as they are commonly called. A small field of about fifty rows was used for this work.

Materials. The field was divided into two plots of about equal size. They were treated with materials as follows:

Plot 1. Dusted. An 85-15 mixture of calcium arsenate and talc was used. The talc was simply a filler or diluent. This mixture was very fine, smooth and easy-flowing.

Plot 2. Sprayed. Calcium arsenate at the rate of 1½ lbs. in 50 gallons of water.

Application. The dusting was done with a power orchard duster and with the regular orchard outlet which is simply a galvanized iron pipe four inches in diameter. Four rows were dusted at each trip through the field. The outlet was held rather close to the ground and swung from side to side. The plants were covered satisfactorily in this way.

The spraying was done with an attachment with two nozzles for each row.

RESULTS

As soon as the dusting and spraying were finished a number of plants in each plot were marked for observation. Plants were selected for this purpose that had a considerable number of adult beetles or larvae on them. There were, however, only a few adult beetles found at that time, most of the insects being in the larval form.

Both methods of application were entirely successful. Within two hours after the application of the dusting material, the larvae were showing effects of the poison. No live larvae could be found the next morning (eighteen hours after application) on either plot.

GENERAL CONCLUSIONS

DUSTING

Apples. During the last three years* apple scab and chewing insects have been controlled satisfactorily by the use of dusting materials. The results have been equal to or better than where dilute lime-sulphur and lead arsenate were used.

No assurance is given that dusting will give satisfactory results in seasons when weather conditions are more unfavorable than in 1917, 1918 and 1919. Weather conditions during 1917 were very favorable to scab development but conditions were not so bad as in 1915 and 1916. In many orchards in 1918 there was very little scab development even on untreated trees. In 1919 conditions were favorable for scab development early in the season and unfavorable later.

The dusting method of application, however, is recommended at this time as a supplement to spraying. Dusting is not a complete substitute for spraying as no dusting material has been developed which can be recommended for the complete control of scale insects. No recommendation can be made covering aphis control because of the lack of injury on check trees.

Cherries. Sulphur dust failed to control shot-hole fungus on English Morello cherries. It also failed to prevent the primary infection of Coniothyrium which developed seriously on trees of this variety. Dilute lime-sulphur controlled shot-hole fungus and prevented any development of Coniothyrium.

Plums. Dusting mixtures composed of sulphur, lead arsenate and tobacco dust have caused no injury to plum foliage (Japanese varieties included).

Peaches. Dusting is not recommended for the control of leaf-curl. No definite recommendation can be made regarding summer dusting of peaches except that dusting materials have caused no foliage injury. The indications, however, are that dusting will give satisfactory control of peach scab, brown rot and curculio. Favorable results have been reported from other states.**

Currants. Sulphur dust and dilute lime-sulphur are not recommended for use on currants to control anthracnose because of foliage injury during hot weather and their failure to control the disease satisfactorily on all varieties. Bordeaux gave almost complete control of anthracnose and caused no foliage injury. It is recommended for use on currants where the leaf-spot diseases cause serious injury. It should be used according to the schedule followed in the experiments reported in this bulletin.

*See Special Bulletin 87 for results of work in 1917.

**Bul. 167, West Virginia Agricultural Experiment Station and Circular 21, Georgia State Board of Entomology.

Potatoes. Dusting potatoes with calcium arsenate for the control of the Colorado potato beetle has given excellent results. Such work can be done with an orchard duster and without any special outlet for distributing the material to each row. If there is much work of this kind to be done, it would probably be better to secure a special attachment.

DRY LIME-SULPHURS AND B. T. S.

The dry lime-sulphurs and B. T. S. have not given satisfactory control of apple scab so they cannot be recommended for the summer spraying of apples as a substitute for lime-sulphur solution.

No experiments have been conducted with this material for the control of San Jose scale as it has not been possible to find enough live scale during 1918 and 1919 for reliable tests of this kind.

ARSENICALS

Lead arsenate is recommended for general use on all kinds of fruits. It has given uniformly better results than any other arsenate.

Calcium arsenate has given excellent results when used on potatoes and other similar crops, but has not always given satisfactory results when used on fruit trees.

Magnesium arsenate has caused severe foliage injury on peaches and apples and has failed to give satisfactory control of codling moth. This material probably will not give such unsatisfactory results in every instance but since there is danger of injury from its use it is not recommended at this time.*

*This material at this time is manufactured in a form which is supposed to be non-injurious to foliage. It cannot, however, be recommended without further tests.

SUGGESTIONS

Dusting may be done when the foliage is either wet or dry. Some growers prefer to dust at night as atmospheric conditions are usually more favorable. Dusting cannot usually be done satisfactorily and economically when there is much wind.

Dusting material should be applied to the trees from two directions for each application. A satisfactory way is to dust with the wind on two different days when the wind is in different directions. When dusting at night the same method is desirable as there is usually a definite air current which causes the dusting material to drift in one direction. Under ordinary conditions it is not necessary to stop at each tree.

The cost per tree for material is much higher for dusting than for spraying, but the cost of application is less for dusting. Dusting can be done very much more rapidly than spraying and because of this it is possible to cover the orchard quickly at critical times and to make extra applications when desirable.

Dilute dusting mixtures are not recommended at this time. More experimental work is necessary before any recommendation can be made.

Ordinary commercial sulphur is not suitable for dusting purposes. Only special dusting sulphur should be used.

Some foliage injury has been caused where spray guns have been used. This can be avoided if proper care is taken. This injury is usually on the lower limbs and where the gun was held close to the tree. Use the driving spray as little as possible, avoid drenching the trees and always use the fine spray when covering parts of the tree close to the operator.